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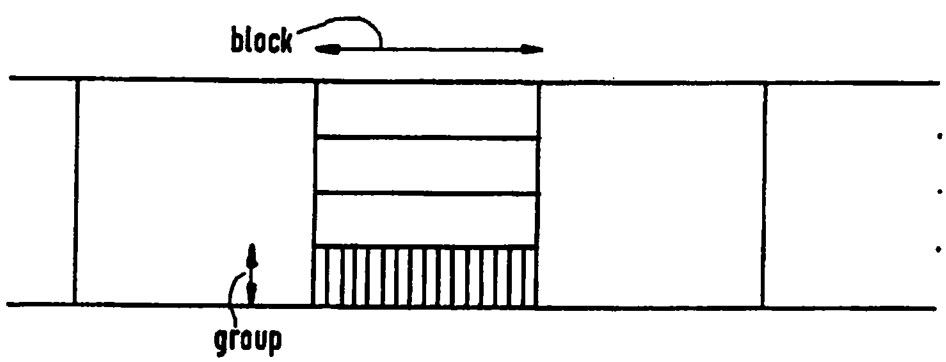

(57) Abstract

A transmission system has a transmitter and a receiver for transmitting data along a transmission channel that has non-uniform quality in time and/or in space as relating to the receiver. The transmitter first distributes the data into successive uniform sized data blocks, and within each block the data into uniform sized groups. Furthermore it encodes within each group the data by an error protective code that is separate from any other group. The transmitter furthermore distributes the encoded data of each group into uniform-sized data packets and assigns the packets from respective groups uniformly and cyclically within a block to a series of time- and/or space-interleaved and multiplexed sub-channels. The system furthermore for each group within a particular block controls a respective different transmission power level.

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Error protected multichannel digital data transmission system and method having graceful degration quality through multi-resolution, and transmitter station and receiver station for use in such system.

FIELD OF THE INVENTION

The invention relates to a transmission system comprising a transmitter station and a receiver station, for transmitting data along a transmission channel that has non-uniform quality in time and/or in space as relating to said receiver station. Traditional digital coding schemes have been designed for point to point transmission. In a broadcast environment this leads to a situation where only a receiver at the edge of the feasible range makes optimal use of the system design. The 'edge' then is represented by those locations or time instants where correct reception is just marginally possible. Under less favourable conditions, reception will suddenly break down. Under more favourable circumstances, either in time or in space, part of the channel transmission capacity is not really necessary, and thus effectively lost. In many situations, the signal-to-noise ratio depends on the frequency actually used. In case of a broadband signal, this would mean that certain parts of the spectrum have an inherently better reception quality than other parts. Moreover, it is known, that at the receiver the signal-to-noise ratio often depends on the actual power level at the transmitter: increased power leads to a higher signal-to-noise ratio. However, usually a transmitter may only dissipate at a prescribed maximum level, which leads inherently to an associated maximum emitted or radiated power. Furthermore in electronics, power saving is a generally valid objective.

SUMMARY TO THE INVENTION

Now accordingly, it is inter alia an object of the present invention in a broadband transmission system of the kind described to allow for so-called 'graceful degradation', wherein the loss of a certain part of the data would not lead to an abrupt transition from full facility reception to complete absence of any received information, whilst using the frequency-dependent transmission quality of the various transmission sub-channels; it should be noted that a complete knowledge on a per sub-channel basis is rarely available. Now, according to one of its aspects, this object is realized by the invention in that it is characterized in that said transmitter station comprises first distributing means for before transmitting distributing said data into successive uniform sized data blocks, and within each

block said data into uniform sized groups, comprising furthermore encoding means fed by said first distributing means for from each group encoding its data by an error protective code that is separate from any other group in the same block, and comprising second distributing means fed by said encoding means for distributing for each group its encoded data into uniform-sized data packets, and assigning means fed by said second distributing means for uniformly cyclically assigning packets from respective said groups within a block to a series of time- and/or space-interleaved and multiplexed sub-channels of said transmission channel, said system furthermore having power control means for controlling among groups within a particular block respective non-uniform transmission power levels. The encoding achieves a certain minimum protection against errors. Through assigning the data of an encoded group to frequency-interleaved sub-channels these data are spread rather equally over an applicable frequency band, thereby spreading the transmission risk. As long as for a particular group the error bound is not exceeded, the data of that group will arrive safely, even when other groups of the same block will not be received correctly. Generally, this means that groups at identical positions in successive blocks will consistently be received, thereby allowing the receiver to organize some kind of operating as based on the correct data. For example in an audio environment, the substituting of lost samples by interpolation will often keep the quality of the reconstructed audio signal, although lower, still acceptable. It is possible to use safer groups for critical data at the expense of less critical data that is assigned to less safe groups. The controlling of the various power levels may be based on experience, on feedback from one or more receivers actually used, or on some other scheme. The separating of the encoding as well as of the power level causes certain parts of the information to be received correctly with a higher probability than other parts. This means that, although certain parts of the information could fail to be received, other parts can still arrive in a recognizable manner. This allows to further realize so-called graceful degradation if the reception quality becomes lower. Only at a still lower power level or signal-to-noise ratio, the transmission would ultimately break down.

Additional spread in signal-to-noise ratio is caused by effects like antenna quality, indoor versus outdoor location of the receiver, effective motion of the receiver with respect to interfering bodies, and in some circumstances, even by such trivialities as a partially empty battery causing a substandard powering voltage. Furthermore, the objective or subjective significance level of various bits in a signal may differ, so that loss of a less significant bit would only cause a reception with lower-quality or less facilities, while the loss of a more significant bit would render the reception less useful.

Advantageously, said transmitter station comprises first distributing means for before transmitting distributing said data into successive uniform sized data blocks, and within each block said data into uniform sized groups, comprising furthermore encoding means fed by said first distributing means for from each group encoding its data by an error protective code that is separate from any other group in the same block, and comprising second distributing means fed by said encoding means for distributing for each group its encoded data into uniform-sized data packets, and assigning means fed by said second distributing means for uniformly cyclically assigning packets from respective said groups within a block to a series of time- and/or space-interleaved and multiplexed sub-channels of said transmission channel, and wherein said transmitter station is arranged for forming transmission symbols with respective different Euclidean signal distances and systematically assigning data bits with respective relevance levels to said signal distances. Here, the power redistribution as it were is on the level of the various parts of the transmission symbols, allowing for the same kind of graceful degradation as considered earlier. The overall power distribution can be combined therewith.

Advantageously, said data derive from user signal representations with a range of at least two bitwise varying significance levels, and said second distributing means are arranged for distributing data bits of at least two significance levels uniformly among the various sub-channels into uniform sized sub-packets per packet, while imparting uniform distributions among said significance levels to said packets, and forming code words for higher significance levels separately from code words for lower significance levels. The separate error-protective encoding is particularly useful for allowing detection of reliable reception or otherwise. Preferably, the code is a block code. Block codes are widely used and well understood. However, in certain cases, convolutional codes or mixed codes could be advantageous.

Advantageously, more significant bits are derived from more relevant signal components that are represented by signal point clustering. By itself, the publication by T. Cover, "Broadcast channels", IEEE Tr.Inf.Th. IT-18, No.1, pp. 2-14, Jan. 1972 has introduced such notion of clustering signal points to clouds. The inventor has found that providing within each group higher levels of error protection to more relevant signal components would automatically provide for graceful degradation, in that the large signal discrimination is more liable to be discerned in the ultimate result of the decoding.

The invention also relates to a method for operating a system according to the foregoing. The invention also relates to a transmitter station and to a receiver station for

use in such system. Further advantageous aspects of the invention are recited in dependent Claims.

BRIEF DESCRIPTION OF THE DRAWING

These and other aspects and advantages of the invention will be explained hereinafter more in detail with reference to the preferred embodiments, and more in particular with reference to the appended Figures, which are respectively:

Figure 1 a schematic diagram of a broadcast system;

Figure 2 a diagram of a transmitted data stream;

Figure 3 a diagram of an interleave scheme;

Figure 4 a schematic diagram of an exemplary signal constellation;

Figure 5 a block diagram of a transmitter station according to the invention;

Figure 6 a block diagram of a receiver station according to the invention;

Figure 7 a dependency diagram between S/N ratio and error rates;

Figure 8 a further dependency diagram between S/N ratio and error rates;

Figure 9 a dependency diagram between S/N ratio and bit rate.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 1 is a schematic diagram of an exemplary broadcast system. At left, a transmitter station 20 has an aerial 22 that emits radio waves in an unspecified frequency range. Now, there is a first receiver station 24 that receives under relatively advantageous conditions. It is relatively close to the transmitter station and it has been provided with a high-sensitivity antenna 26. Further, a second receiver station 30 receives under relatively disadvantageous conditions. It is relatively distant from the transmitter station, it is situated at the far side of obstacle 28, is located inside a building 32, and it has only a relatively low-performance antenna 34. In fact, this receiver station may even be portable. Obstacle 28 may be constituted by various geographical elements, such as other houses or buildings, raised or depressed parts of the earth's surface, etcetera. Of course, intermediate situations between best and worst may exist. The exact attenuation mechanism is of extremely complex nature, and may include multipath phenomena, reflections, etcetera.

A similar variation in transmission quality may exist in case of point-to-point transmission, and in principle, for almost every kind of transmission medium. In practical terrestrial circumstances, variation of signal-to-noise ratio between different

receivers can be several tens of dB, and the ratio may depend on the actual position of the receiver, as well as on the actual frequency sub-band. The present invention provides various mechanisms realizing a trade-off between varying transfer characteristics to allow maximum overall transfer effectivity. In particular, the present invention provides a channel coding scheme allowing a trade-off between signal-to-noise ratio and bit-rate, preferably combined with a multi-resolution scheme. The present invention also provides a way to in an environment as sketched with reference to Figure 1, let both stations receive respective selections of the total information. A specific example would be a digital video program, wherein the first station takes advantage of its privileged location for realizing a high quality reception, whereas the second station is able to receive the same program, be it at a somewhat lower quality. The degradation in quality is realized by so-called scalable source coding and may be defined in many different ways, such as:

- the number of bits per sample is lower,
- the number of samples (such as pixels per frame) is lower,
- certain parts or features of the information are not used: for example, the low-significance bits of an audio channel can be encoded to contain another audio channel. The second station then would have to ignore this facility.

Figure 2 is a diagram of a transmitted data stream. The complete stream is mapped on an area along the horizontal time axis. The full band is divided into uniform blocks that succeed each other in successive time slots from left to right, within each block the area is proportional to the number of transmitted bits. On a next lower level, each block is divided into a column of uniform-sized groups. In this Figure their number has been shown as being equal to four, but in the preferred embodiment of Figure 3 it is equal to fifteen. On a still lower level, each group is divided into a row of uniform-sized packets. In this Figure their number has been shown as being equal to sixteen, but in the preferred embodiment of Figure 3 it is equal to sixty-three. In Figure 3, each of the 15x63 packets is transmitted on a respective unique frequency band, while packets of a number of corresponding groups in successive blocks constitute symbols of an error protected block code. Always a symbol is constituted from information transmittted at a single frequency.

Now, the mapping of an input stream of information bits is as follows. First, the information bits are separated into as many subsets as there are distinct levels of significance that will be modulated in respective different ways in the manner taught with reference to Figure 4. For each level of significance, the bits are grouped in six-bit symbols. For each level of significance, six-bit symbols from different frequency bands are encoded

according to an appropriate error protective code. In the example, this is a uniform Reed-Solomon code with a code word length of 63 symbols. The mapping of the various code words on the groups will be discussed with reference to Figure 3. Next, the bits are assigned to the time slots shown in Figure 3, thereby constituting four-bit packets per time slot and per sub-channel. Finally, from each of the packets a respective OFDM symbol is formed. The error protective encoding used allows separate detection of correct or correctable transmission for each of the groups and for each of the three significance levels therein. Also, incorrectable errors are detected separately. Different groups within a single time slot are encoded fully independently from each other. This means that the composition of the various groups must be uniformly selected from the input stream of user bits.

Figure 3 is a diagram of an interleave scheme for one of the blocks shown in Figure 2. The vertical axis represents the frequency, that is distributed into 63 sets of 15 contiguous sub-channels each, cf. the arrow '15'. All sub-channels have uniform widths. The horizontal arrow along the bottom of the Figure represents time, each vertical band representing a basic time interval. Within each vertical band, each sub-channel represents a single OFDM symbol that transmits $2+1+1=4$ four data bits as will be discussed hereinafter. The dark rake-like shape with 63 horizontal extensions represents the protection format by codewords of an error protective block code, of which the temporal extension will be discussed hereinafter. The codewords of this block code are separate from corresponding codewords pertaining to each of the other fourteen rake-like structures not shown for simplicity. Each column therefore contains parts of 15 rake-like shapes similar to the one shown, successive ones of these rake-like shapes being staggered vertically over one sub-channel. The vertical part of the rake-like shape as shown is notional only. For each horizontal extension of the rake in question, each column, equal to one basic time interval, has one OFDM (Orthogonal Frequency Division Multiplex) symbol representing four code bits, distributed over the three significance levels as discussed with reference to Figure 4, infra. For each rake-like shape of 63 sub-channels three [63, 55, 9] Reed-Solomon codes over the Galois Field GF(2^6) are used, one for the 4-PSK clouds, one for the 2-AM sub-clouds, and one for the 2-AM signal points. The 4-PSK clouds contribute two bits to each column, the 2-AM subclouds contribute one bit, and the 2-AM signal points also contribute one bit. Thus the six-bit symbols for the 4-PSK clouds extend over three successive columns per horizontal extension of the rake-like structure in question. The six-bit code symbols for the 2-AM sub-clouds and for the 2-AM signal points, respectively, each extend over six columns. Thus each of the latter symbols corresponds in time to two symbols, and also to

two code words, pertaining to the 4-PSK clouds. The bits belonging to a particular six-bit symbol are transmitted in the same sub-channels in consecutive time units.

In this particular example, the total bandwidth is 8MHz, subdivided into 1024 sub-channels of which **15x63=945** sub-channels are effectively used, making the effective bandwidth 7.38 MHz. The individual sub-channels have a uniform bandwidth of 7812.5 Hz each. Symbol time was chosen as $T_S = 160\ \mu$sec.

Now, within a single rake-like shape of 63 sub-channels all sub-channels are transmitted with the same power, but between various rake-like shapes a redistribution of power can be controlled according to the principles that will be discussed later. This power level may be set once and for all, or it may be adapted to various types and situations of use, or it may be distributed in a non-uniform manner. Further, a modulating system similar to Figure 4 has been implemented. Through this modulation, the information represented by the distribution among the clouds is most robust against interference and attenuation. On the other hand, the information represented by the distribution among the 2-AM points is least robust against interference and attenuation. Therefore, a receiver for a robust signal only, such as used in a portable, distant, or other receiver that needs only low signal strength has only a 4-PSK demodulator. A receiver that makes use of a more refined signal, such as used in a nearby station or an advanced station such as a High Definition TeleVision receiver set may advantageously use the full signal information content while distinguishing between various amplitude levels. According to the organization of Figure 4, also an intermediate case has been provided for. The scheme is effected by from a series of successive OFDM packages composing the associated bits until a complete six-bit symbol is realized. Subsequently, an array of those symbols is combined to a code word and decoded.

Now in the example, three consecutive 4-PSK clouds in a particular sub-channel correspond to a single Reed-Solomon code symbol on the cloud level. Likewise, six consecutive sub-cloud choices in a particular sub-channel define a Reed-Solomon code symbol on the sub-cloud level and six consecutive choices of a signal point within a sub-cloud define a Reed-Solomon code symbol at the lowest level.

Figure 4 is a schematic diagram of an exemplary signal constellation to be used with a preferred embodiment of the invention, see also the Cover reference, supra. The global range of useful signal-to-noise ratios is defined by the cloud structure of the set of signals. The example has three levels, to wit:

-- There are four clouds such as **40**. The distribution of signal points over the four clouds may thus represent two bits of data. In an embodiment, the respective

clouds are realized by phase-shift keying with as shown by the arrow length a minimum Euclidean distance of size 12 between the clouds. This Euclidean distance indicated as **41** is given by the minimum number of elemental steps that is necessary to change a signal point of a first cloud into a signal point of a different cloud, and physically is proportional to the square root of the associated signal energy.

-- Each cloud **40** consists of two sub-clouds such as **42**, which subdivision represents one further bit. The sub-clouds are defined by amplitude modulation with a minimum Euclidean distance of size 4 between the sub-clouds; therefore, the square root of the associated energy is three times smaller than the one associated with the distance between the clouds.

-- Each sub-cloud consists of two points, which sub-division represents still one further bit. The sub-division is defined by amplitude modulation with a Euclidean distance of 1 between the points. Therefore, the square root of the associated energy is four times smaller than the one associated with the distance between the sub-clouds. Together, there are sixteen different points that collectively define a four-bit value. These four bits are now divided into three different categories with respective different resolutions.

Although this example is based on a three level star configuration, other configurations give advantageous results as well, the effective outcome depending on the particular circumstances, number of channels, relative levels of significance, and other aspects. A particular simple solution is to provide only two levels. This can be realized in that the clouds **40** in Figure 2 each have the form of a square, with points on each corner of the square, the respective edges of the square being parallel to and perpendicular to, respectively, arrow **41**. Rotating the small square over 45° is feasible as well. Another solution is based on a ring-type constellation among the various signal points. From general transmission praxis it is known that time- and space-multiplexing and -interleaving can for a good deal be interchanged.

Figure 5 is a block diagram of a transmitter station for use in a system according to the invention. Block **100** represents a source of digital data to be transmitted. In this example the data is split into three sub-categories, that will be transmitted according to the three levels of significance discussed with reference to Figure 4. In distributor block **102** the three sub-categories are separated. In encoding block **103** each respective data category is encoded separately according to three Reed-Solomon block codes, one respective code for

each of the three above significance levels. In contradistinction to Reed-Solomon codes, other codes, such as convolutional codes, or a mixture of block codes and convolutional codes may be used as well. The constitution of the code is discussed elsewhere. Next, the encoded symbols are fed to block **104** that has 15 sub-blocks as indicated, each of which receives complete code words, according to a ratio of two from the highest significance level, one from the next lower significance level, and one from the lowest significance level. Each of the fifteen sub-blocks will now output the necessary information for its own rake-like structure shown in Figure 3. The output from the sub-blocks of block **104** are the representations of the OFDM symbols shown in Figure 4. These are output in the correct order, according to the columns of Figure 3. Next, in block **106**, for each of the fifteen rake-like structures the power level for the modulation can be controlled separately. Next, the outputs from amplifiers **106** are fed to frequency division multiplexer **108**, which interrogates each sub-block 63 times, according to the number of extensions of the associated rake-like structure. The multiplexer in its turn feeds output stage **110**, that may feed a broadcast antenna not shown. The various parts **106**, **108**, **110** have been indicated separately for better comprehension thereof, but it is to be understood that various other mappings may be appropriate, and are open to the skilled OFDM practitioner. The power level in block **106** can be controlled to need. It may be uniform across the groups, but may alternatively could be controlled in a non-uniform manner, as will be explained with reference to Figure 8.

Figure 6 shows a block diagram of a receiver station for use in a system according to the invention, for example in conjunction with the transmitter station of Figure 5. Here, the data are received on antenna amplifier **112**. Block **114** is the counterpart of block **108** and distributes the various frequency sub-bands among the sub-blocks in block **116** for demodulating and decoding. Each of the latter sub-blocks demodulates the OFDM symbol and undertakes to separate the bits constituting the packets thereof. Next, from successive time slots, the code symbols are assembled, and the codewords of the three significance classes reconstituted. The codewords of the three classes are forwarded to the three sub-blocks of block **120**, each of which undertakes to decode the codewords received. For the three classes respective different decoding strategies may be applied. Inter alia, for each of the three classes, decoding results of contiguous codewords of the same significance class may codetermine the decoding strategy. The result may be, that output block **122** receives one, two, or three reliable classes of bits. These are forwarded to user block **124** for further use that by itself does not pertain to the present invention. As discussed earlier, for certain receiver devices it may be useful to provide less than all three decoders in block **120**,

because the device in question does not need the sophisticated reception level, but may perform in a standard manner with only a limited fraction of the transmitted information. For other devices, all three sub-blocks of block **120** are present, but the quality or accessory facilities of the reception may vary on the basis of the number of bit categories that are received in a reliable manner.

Figure 7 shows a dependency between wideband S/N ratio and error rates on a per bit level basis under various parameter conditions, but without power redistribution among the various group transmissions. The wideband S/N ratio, horizontally in dB, compares to the unweighted S/N ratio in analog TV broadcast and thus corresponds to broadcasting power cost. In digital transmission it would relate to the S/N ratio on a symbol level. Note that the sub-channel level and cloud structure may have respective different Euclidean distance structures as explained with reference to Figure 4, each time influencing the associated error ratios.

The vertical axis lists error event rate on a per bit basis. First, the situation without error protective codes is considered. The asymptote at low power for curves **60** (points) and **62** (subclouds) is at 0.5, meaning that decoded bits are totally random. The low-power asymptote for curves **64** (clouds) and **66** (classical 4-PSK) is lower. In the example, each sub-channel has AWGN (Additive White Gaussian Noise) and the sub-channels within each group have uniform power. The aggregate signal before encoding corresponds to 11.34 Mbaud for the 4-PSK signal and the cloud signal, and to 5.67 Mbaud each for the subclouds and points. In this example, the differences between the three successive performance curves (60-64) are about 10 dB at low error rate (error rate below 0.01). Here, the information was encoded with the Reed-Solomon code according to the encoding discussed supra. An error rate can be related to the mean time between successive errors or average number of errors per second.

Further, there is error propagation at the output of the decoder, because an incorrectable error makes also the remainder of a VLC block irrecoverable. This means that the probability of an error event is more important than the size of the associated error. Now, if the Reed-Solomon codes are used (at 6 x 63 = 378 bits per code word), any irrecoverable error will mean 378 unreliable bits. Such error may at most start every 378 bits at probability $378^{-1} = 0.0026$. This is the horizontal asymptote of the curves for the RS-protected signals. Of these, curve **68** relates to the clouds (▸**64**), curve **70** relates to the subclouds (▸**62**) and curve **72** relates to the individual points (▸**60**). The coding gain at low error rate, the bottom edge of the chart, is about 5 dB at each of the three coding levels.

This means that equal performance to the uncoded case necessitates about 5 dB lower S/N ratio, and in consequence, less transmitting power. Moreover, it can be seen that an S/N ratio greater than 34 dB would give a guaranteed overall error rate better than 10^{-9}, whereas for the other two significance levels, ratios of only 22 dB and 12 dB, respectively, would be needed.

Figure 8 is a further dependency diagram between S/N ratio and error rates, based on curves **68**, **70** and **72** from Figure 7, however, with power level variation applied between the various groups within a block. This also means power variation among coexistent ones of the rake-like structures in Figure 3. The horizontal line is the same one from Figure 6 with an error probability of 0.0026. Furthermore, for each of the cases "clouds" (at relatively low SNR ratios, "sub-clouds" and "points" (at relatively high SNR ratios), a bundle of curves results. The parameter among the various curves of each bundle has been chosen in such a way, that the minimum difference in S/N ratio between two contiguous sub-channels of the same bundle is 0.6 dB. The consequence for the power level associated to each respective curve than is straightforward, and the necessary power level may be determined either by measurement or by a straightforward calculation. However, the total aggregate power level is invariant and results in the same average S/N ratio. Each curve at left corresponds to a bit rate of 660 kBaud, so that the lowest set of sub-channels corresponds again to 9.9 MBaud. In this case, an error event rate of 10^{-9} corresponds to about once every 25 minutes. Likewise, each of the curves indicated by "subclouds" or "points" corresponds to 330 kBaud. This means that upgrading the S/N ratio will improve the performance of the system in a more or less continuous way, successively further groups attaining an acceptable level. In the other direction, successive further groups will fall below an acceptable error level, as signalled by the decoding, and will be taken away from the useful data stream. In this way, a graceful degradation system will indeed be realized. Similar argumentation will apply at other levels of acceptable error rates. The mapping of the various user facilities, quality determining bit levels, etcetera, on the successive ones of the 45 curves shown may in principle be arbitrary. This means that for each such facility or level the required bit rate determines the number of curves starting from the left. In this way, the curves are assigned in sequence, always the next one representing at most the same level of significance as its predecessor. From the above, it is clear that the 'graceful degradation' feature can be attained in various different ways:

- with a single level of the distance within the OFDM symbols of Figure 4, but with power redistribution among the various rake-like structures;

- with different values for the respective distances within the OFDM symbols of Figure 4, but without the power redistribution discussed with reference to Figure 8;

- with different values for the respective distances within the OFDM symbols of Figure 4, as well as but with the power redistribution discussed with reference to Figure 8. As an alternative, the power level redistribution need not be effected on the OFDM symbols as a whole, but may alternatively be applied to only one or of the signal distance levels. For example, in Figure 4, the clouds can be put further away from each other, while the point constitution within each respective cloud remains the same. Note that the distances within the OFDM symbols need not be quantized, but may as well be analog. Various other modifications to the OFDM symbol shape are within the scope of the present invention.

Figure 9 is a dependency diagram between wideband S/N ratio and bitrate according to the scheme of Figure 8, while assuming an acceptable error event rate of 10^{-9}. The three clearly separable sections stem from the "clouds" (low S/N ratio), "subclouds" (middle S/N ratio), and "points" (high S/N ratio), respectively. Note that the bitrate increase at lower value of the S/N ratio is twice as high as for higher ratios, due to the double transfer capacity relating to the clouds as compared with the other two cases. Note the steepness of the increase: between S/N ratios 10 and 20 dB, the transfer capacity increases by a factor of about 6.

CLAIMS:

1. A transmission system comprising a transmitter station and a receiver station, for transmitting data along a transmission channel that has non-uniform quality in time and/or in space as relating to said receiver station, characterized in that said transmitter station comprises first distributing means for before transmitting distributing said data into successive uniform sized data blocks, and within each block said data into uniform sized groups, comprising furthermore encoding means fed by said first distributing means for from each group encoding its data by an error protective code that is separate from any other group in the same block, and comprising second distributing means fed by said encoding means for distributing for each group its encoded data into uniform-sized data packets, and assigning means fed by said second distributing means for uniformly cyclically assigning packets from respective said groups within a block to a series of time- and/or space-interleaved and multiplexed sub-channels of said transmission channel, said system furthermore having power control means for controlling among groups within a particular block respective non-uniform transmission power level.

2. A transmission system comprising a transmitter station and a receiver station, for transmitting data along a transmission channel that has non-uniform quality in time and/or in space as relating to said receiver station, characterized in that said transmitter station comprises first distributing means for before transmitting distributing said data into successive uniform sized data blocks, and within each block said data into uniform sized groups, comprising furthermore encoding means fed by said first distributing means for from each group encoding its data by an error protective code that is separate from any other group in the same block, and comprising second distributing means fed by said encoding means for distributing for each group its encoded data into uniform-sized data packets, and assigning means fed by said second distributing means for uniformly cyclically assigning packets from respective said groups within a block to a series of time- and/or space-interleaved and multiplexed sub-channels of said transmission channel, and wherein said transmitter station is arranged for forming transmission symbols with respective different Euclidean signal distances and systematically assigning data bits with respective relevance levels to said signal distances.

3. A transmission system as claimed in Claim 2, said system furthermore having power control means for controlling for each group within a particular block a respective different transmission power level.

4. A transmission system as claimed in Claims 1, 2 or 3, wherein said data derive from user signal representations with a range of at least two bitwise varying significance levels, and said second distributing means are arranged for distributing data bits of at least two significance levels uniformly among the various sub-channels into uniform sized sub-packets per packet, while imparting uniform distributions among said significance levels to said packets, and forming code words for higher significance levels separately from code words for lower significance levels.

5. A transmission system as claimed in Claim 4, wherein the number of said levels is exactly 3.

6. A transmission system as claimed in any of Claims 1 to 5, wherein said encoding means implement a block code, code words of said block code being mutually synchronized on the level of said blocks.

7. A system as claimed in Claim 6, wherein said encoding means are arranged for implementing a systematic code on a symbol level.

8. A transmission system as claimed in any of Claims 1 to 7, wherein said path is a broadcast path and said data is distributed over a plurality of channels by way of Orthogonal Frequency Division Multiplexing (OFDM).

9. A transmitter station for use in a transmission system as claimed in any of Claims 1 to 8.

10. A receiver station for use in a transmission system as claimed in any of Claims 1 to 8.

11. A method for transmitting data along a transmission channel that has non-uniform quality in time and/or in space, said method comprising the steps of:

- before transmitting, distributing said data into successive uniform sized data blocks, and within each block said data into uniform sized groups,
- encoding each group by an error protective code that is separate from any other group in the same clock, next distributing for each group its encoded data into uniform-sized data packets, and cyclically assigning packets from respective said groups within a block to a series of time and/or space interleaved and multiplexed sub-channels of said transmission channel, and controlling power among respective groups within a particular block at respective non-uniform levels.

12. A method as claimed in Claim 11, furthermore forming transmission symbols with respective different Euclidean signal distances, and systematically assigning data bits with respective relevance levels to said signal distances.

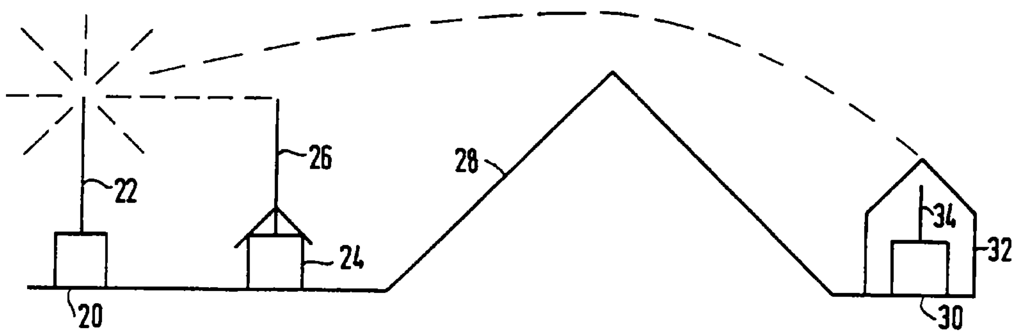


FIG.1

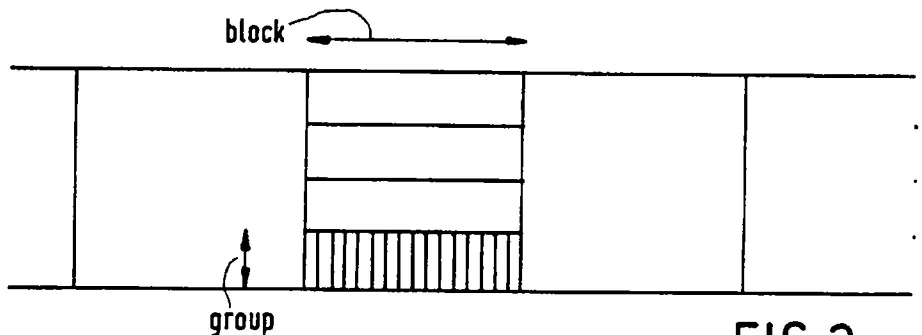
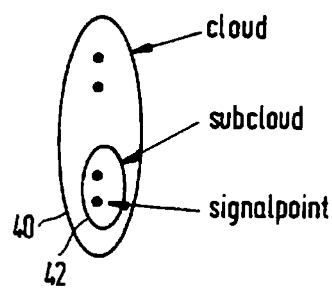


FIG.2



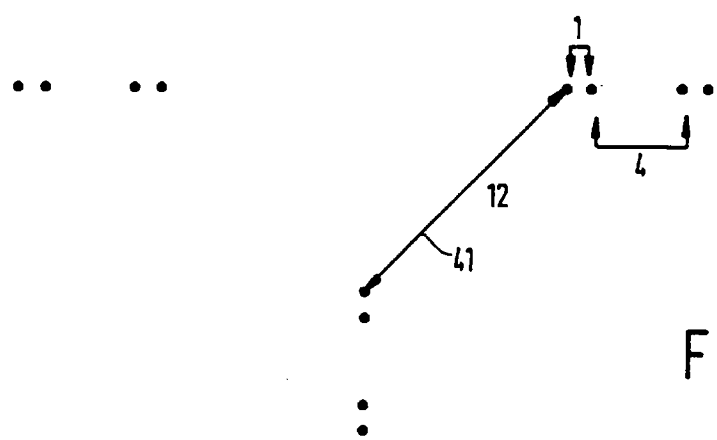


FIG.4

Interleave Scheme

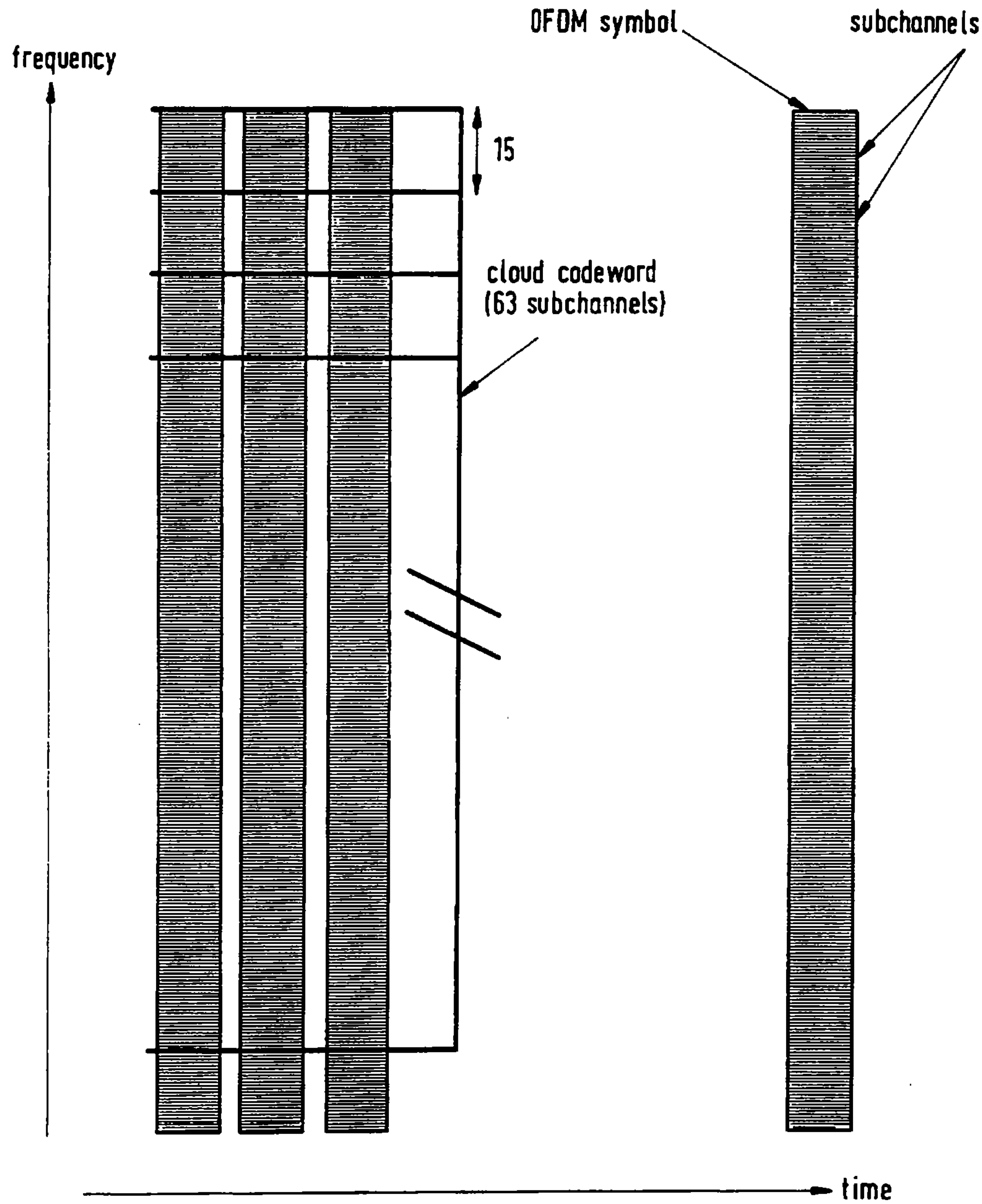


FIG.3

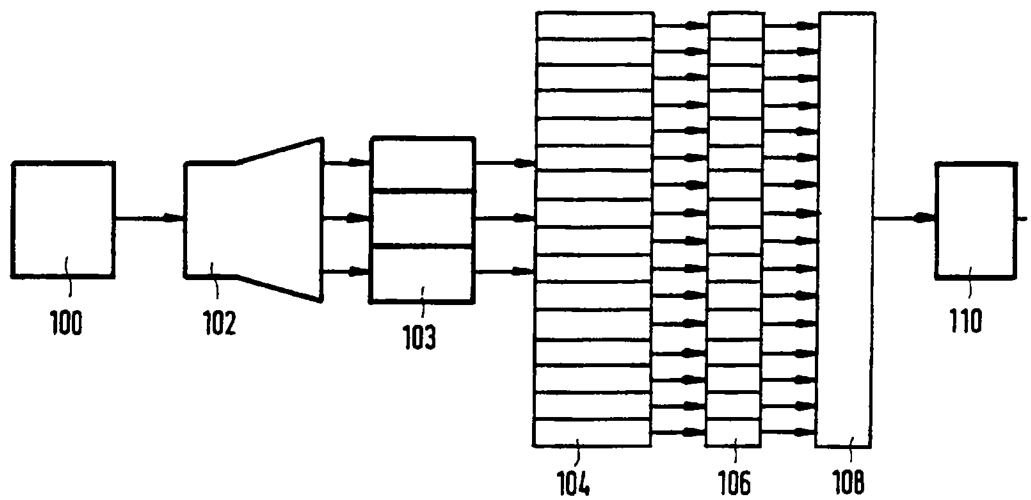


FIG. 5

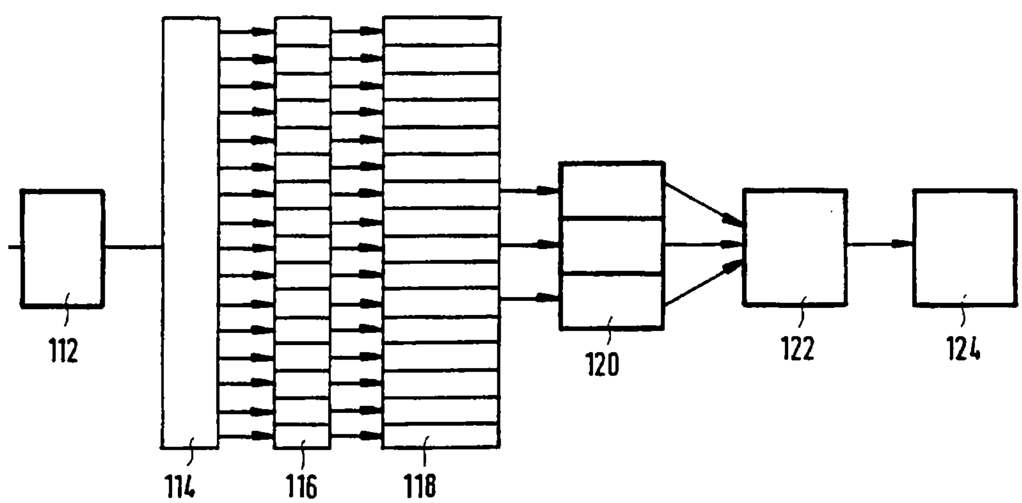


FIG. 6

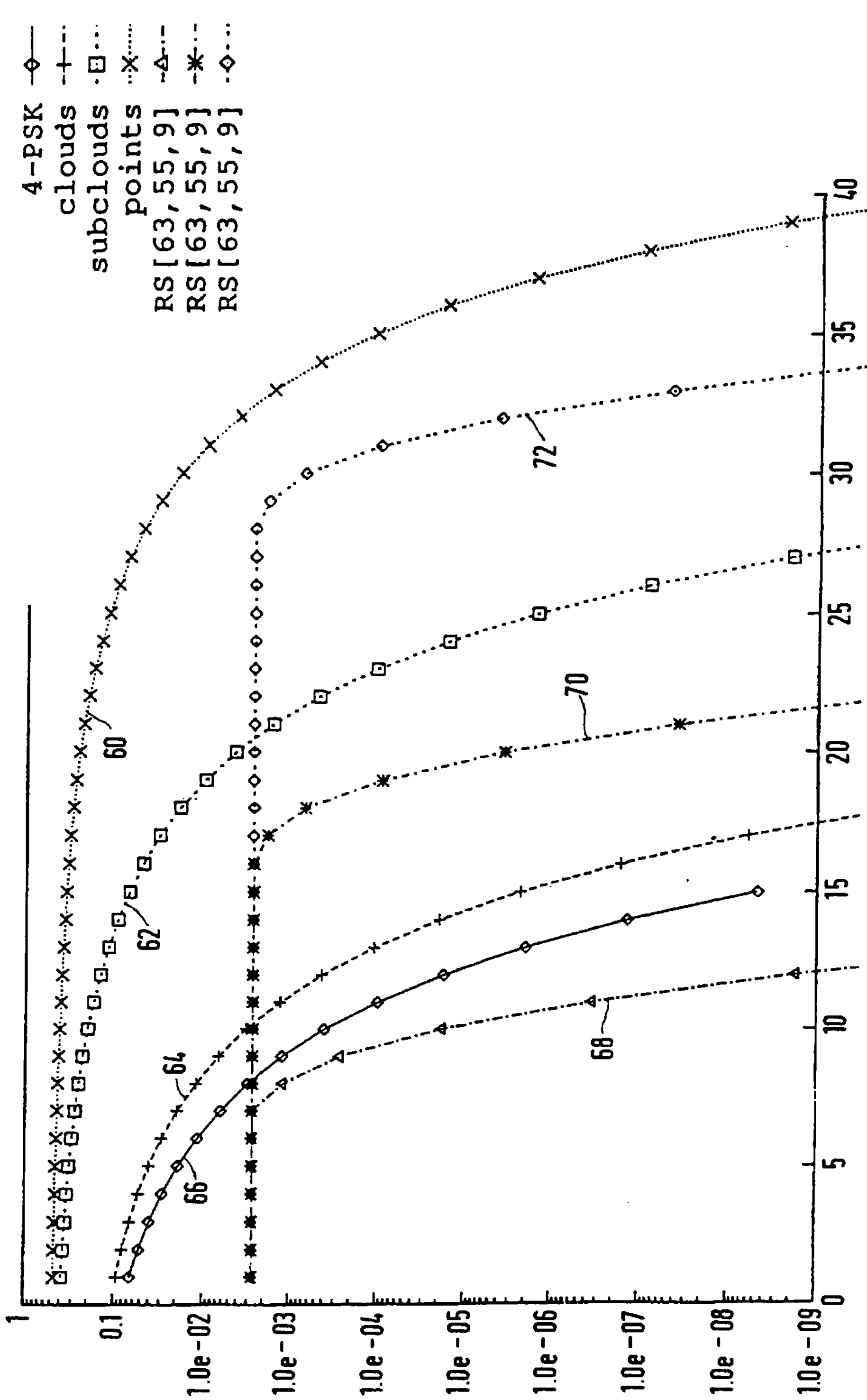

4-PSK
clouds
subclouds
points
RS[63,55,9]
RS[63,55,9]
RS[63,55,9]
1
0.1
1.0e-02
1.0e-03
1.0e-04
1.0e-05
1.0e-06
1.0e-07
1.0e-08
1.0e-09
0
5
10
15
20
25
30
35
40
SNR
60
62
64
66
68
70
72

FIG. 7

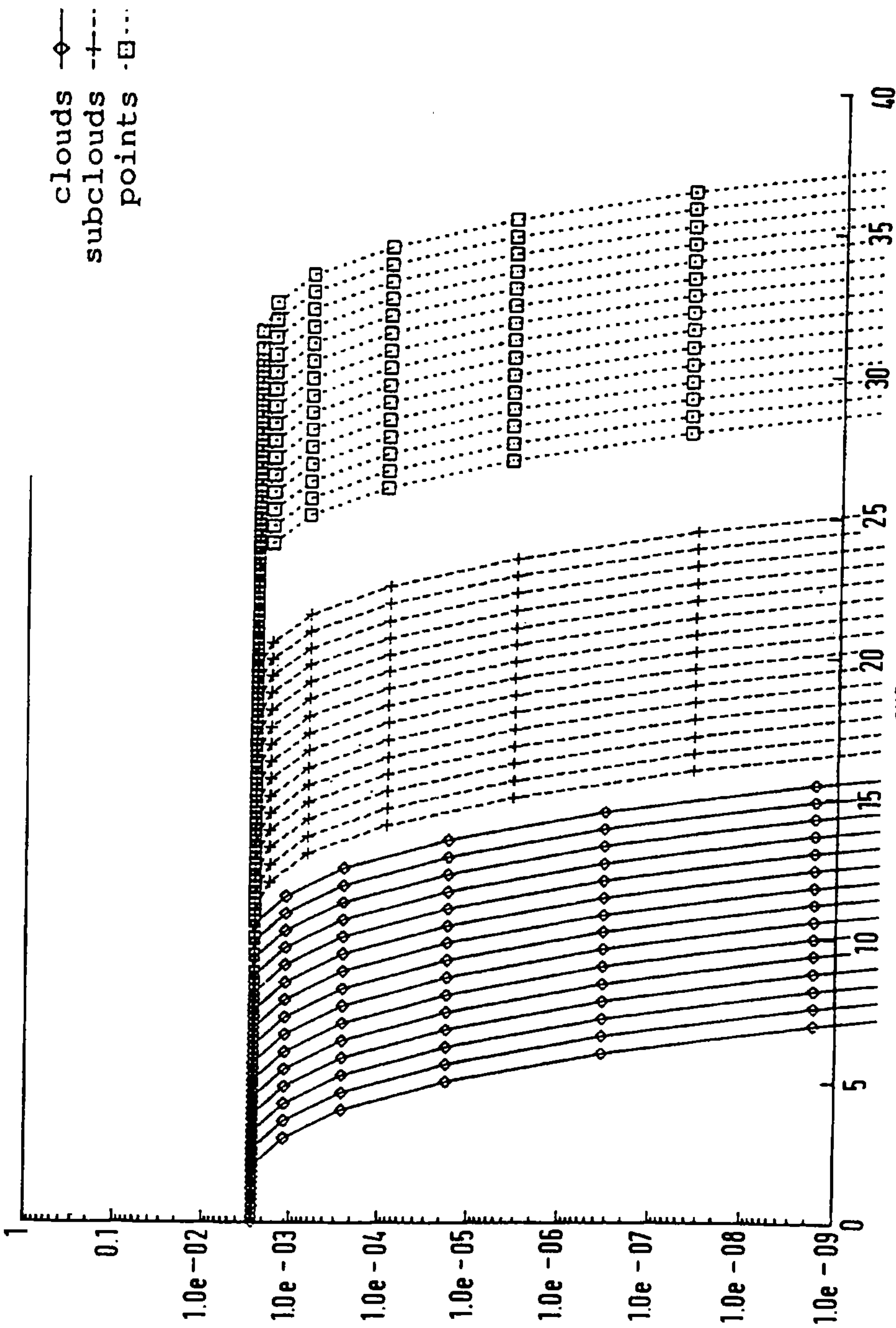

clouds
subclouds
points
1
0.1
1.0e-02
1.0e-03
1.0e-04
1.0e-05
1.0e-06
1.0e-07
1.0e-08
1.0e-09
0
5
10
15
20
25
30
35
40
SNR

FIG.8

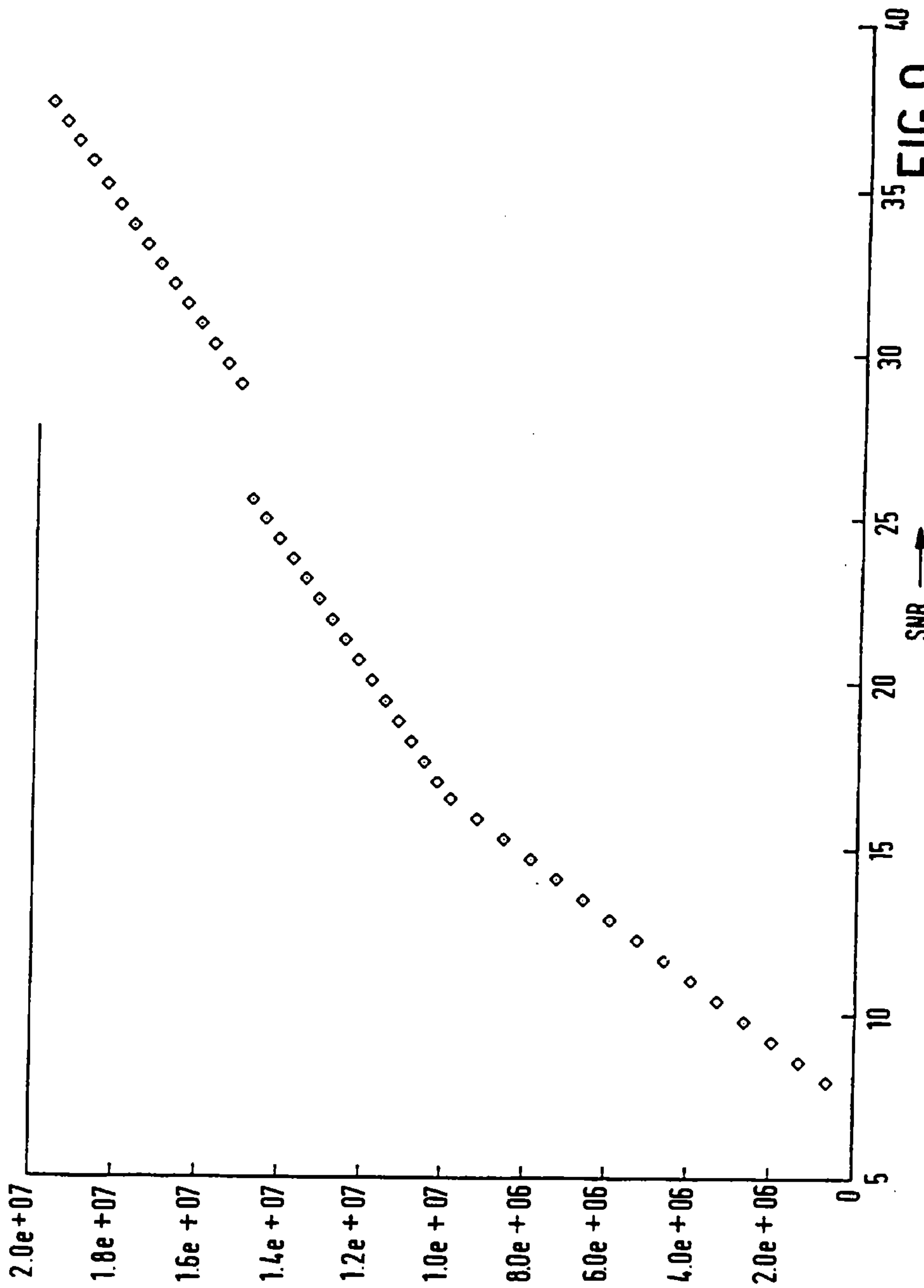

2.0e+07
1.8e+07
1.6e+07
1.4e+07
1.2e+07
1.0e+07
8.0e+06
6.0e+06
4.0e+06
2.0e+06
0
5
10
15
20
25
30
35
40
SNR

FIG.9